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# Distribution and prevalence of transmissible venereal tumor in the Colombian canine population¤

***Distribución y prevalencia de tumor venéreo transmisible en la población canina colombiana***

***Distribuição e prevalência do tumor venéreo transmissível na população canina colombiana***

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**Abstract**

**Background**: Canine transmissible venereal tumor (CTVT) is perhaps the oldest known canine neoplasia. It is spread by cell allogeneic transplantation among susceptible animals. It is globally distributed, mainly in urban areas with high populations of stray dogs. **Objective**: To estimate the current distribution and prevalence of CTVT in Colombia. **Methods**: After analyzing the literature, we obtained epidemiological information on CTVT from 152 veterinarians in five Colombian regions via an electronic form (using Google Forms). This analysis confirmed that CTVT is endemic in the inhabited regions of Colombia and is highly prevalent in the Andean region, the most populated region in the country. **Results**: For the reported cases of CTVT, no significant differences were found in terms of animal gender, reproductive status, or origin. An association was found between the number of CTVT cases and concomitant infectious diseases. Results also showed that vincristine is the most effective therapy for CTVT and resistance is not a serious problem in Colombia. **Conclusion**: Our results confirm that CTVT is endemic in the country, coinciding with global analysis of the factors that enable the continued existence of the disease, and implies that stray dogs are the reservoir. Accordingly, we recommend that canine control policies be introduced in Colombia.

**Keywords:** C*hemotherapy resistance, epidemiology, survey, transmissible cancer, tumoral biology.*

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**Resumen**

**Antecedentes**: el tumor venéreo transmisible canino (TVTC) es quizá la neoplasia más antigua del canino. Se transmite por un transplante alogénico entre los animales susceptibles. Su distribución es mundial, principalmente en áreas urbanas con alta población de perros callejeros. **Objetivo**: estimar la actual distribución y prevalencia de TVTC en Colombia. **Métodos**: en este estudio, además de revisar la literatura, se obtuvo información epidemiológica del TVTC de 152 veterinarios en cinco regiones de Colombia, mediante formulario electrónico (usando Google Forms). **Resultados**: este análisis confirma que TVTC es endémico en las regiones habitadas de Colombia y es altamente prevalente en la región Andina, la región más poblada del país. Para los casos reportados, no se encontraron diferencias significativas respecto al género de los animales afectados, su estado reproductivo o su origen. Se encontró una asociación entre los casos de TVTC y las enfermedades infecciosas concomitantes. Los resultados muestran que la vincristina es la terapia más efectiva contra el TVTC y el fenómeno de resistencia no es un problema serio en Colombia. **Conclusión**: los resultados confirman que el TVTC es endémico en el país lo cual coincide con el análisis global de los factores que permiten que la enfermedad continúe existiendo, e implica que los perros callejeros son el reservorio de la enfermedad. En consecuencia, se recomienda que se implementen políticas de control de caninos callejeros en Colombia.

**Palabras clave:** *biología tumoral, cáncer transmisible, encuesta, epidemiología, resistencia a la quimioterapia*.

**Resumo**

**Antecedentes**: o tumor venéreo transmissível canino (TVTC) é talvez a neoplasia mais antiga dos caninos. É transmitido por um transplante alogênico entre animais susceptíveis. Sua distribuição é mundial, principalmente em áreas urbanas com altas populações de cães de rua. **Objetivo**: estimar a atual distribuição e prevalência de CTVT colombiano. **Métodos**: neste estudo, além de uma revisão da literatura, informação epidemiológica de TVTC foi obtido de 152 veterinários em cinco regiões da Colômbia, por meio de um formulário eletrônico (usando o Google Forms). **Resultados**: esta análise confirma que TVTC é endêmica nas regiões habitadas da Colômbia é altamente prevalente na região andina, a região mais populosa. Para os casos relatados, não houve diferenças significativas em relação ao sexo dos animais afetados, o seu estado reprodutivo nem do sua origem. Uma associação entre os casos de TVTC e doenças infecciosas concomitantes foi encontrada. Os resultados amostram que a vincristina é terapia mais eficaz contra o TVTC e o fenómeno de resistência não é um problema grave na Colômbia. **Conclusão**: os resultados confirmam que a TVTC é endémico no país, o qual coincide com a análise global dos fatores que permitem que a doença continue existindo e implica que os cães de rua são o reservatório da doença. Consequentemente, recomenda-se que políticas de controle sejam implementadas para cães de rua na Colômbia.

**Palavras-chave:** *biologia tumoral, câncer transmissível, epidemiologia, pesquisa, resistência à quimioterapia.*

## Introduction

Canine transmissible venereal tumor (CTVT), also known as infectious lymphosarcoma venereum lymphosarcoma, myxosarcoma, or Sticker's sarcoma (Moulton, 1990), venereum granuloma, condyloma, or infectious sarcoma (Mandewell and Theilen, 1987), is a transmissible cell neoplasm that affects canines worldwide and is more common in tropical and subtropical areas, particularly urban areas with large populations of stray dogs (Mialot, 1984). It is the oldest known cancer in dogs, originating from a wolf or a dog in East Asia more than 10,000 years ago; nevertheless, the exact date of CTVT appearance is still debated and is being estimated to have occurred between 6,000 and 11,000 years ago (Murgia *et al.,* 2006; Murchison *et al.,* 2014; Decker *et al.,* 2015; Ostrander *et al.,* 2016). Over time and due to a downregulated expression of the major histocompatibility complex, it was transmitted to other dogs (Murgia *et al.,* 2006) and no naturally occurring CTVT cases have been reported in wild canids (Strakova and Murchison 2014). CTVT is transmitted naturally through sexual intercourse and usually affects the genital system in sexually mature animals. However, when the neoplasia is licked or sniffed, it can be transplanted to the skin or nasal mucosa

(extragenitally) and, in some severe cases, may metastasize to internal organs (Moulton, 1990).

Strakova and Murchison (2014) determined that CTVT is present in at least 90 countries and widely distributed throughout the world. In Colombia, despite of the large number of cases routinely observed, CTVT appears to be underdiagnosed due to the limited literature available on the subject. Sánchez *et al.* (2014) reported that the disease had 2.7% prevalence in Boyacá, with genital presentation in all cases. On the other hand, 8.6% cancers diagnosed in dogs at Universidad de los the Llanos corresponded to CTVT, with most dogs affected from urban areas (Bravo *et al.,* 2010). Universidad de la Amazonia reported one case and, although the epidemiologic situation is unclear, its presence is possibly related to stray urban animals (Ramirez et al., 2015). A case of extragenital CTVT presentation was reported by Martinez *et al.* (2002) in Monteria in a female dog with a skin lesion and compromised ipsilateral inguinal lymph node. Similarly, Salamanca et al. (2008) reported a case of pulmonary metastases of a CTVT in Villavicencio.

Review studies are important for improving our understanding of certain diseases. Catanzaro *et al.* (2016), for example, determined the attitudes, opinions, and knowledge of Italian veterinarians on abdominal visceral pain in canine practice, whereas; Wang *et al.* (2014) used a cohort study to determine the health of urban populations, identifying risk factors for cardiovascular disease in Chinese workers. Likewise, Hang *et al.* (2015) used online forms and cytological images to determine the degree of knowledge of practitioners on cytological diagnosis and define the accuracy of the diagnoses. Descriptive and analytical clinical epidemiology studies can help identifying disease distribution and presentation, laying the groundwork for research into ways to control or eradicate diseases.

In Colombia, there is limited research on the biological and epidemiological behavior of CTVT. This information is required to establish the endemic nature of the disease and therapeutic possibilities for control. In Brazil, where some degree of resistance to treatment with vincristine sulfate has been reported, resistant CTVT has become a major problem for clinical management, even leading to animal euthanasia. Thus, the aim of the present study was to provide epidemiological and clinical information on CTVT, as well as its distribution and relative prevalence in different regions of Colombia. We also want, to inform veterinarians about the potential risk of resistant CTVT strains in our country and generate hypotheses for future research aimed at understanding the biological behavior of this entity.

## Materials and Methods

A cross-sectional study was used to investigate the epidemiological and clinical characteristics of CTVT in Colombia. Using Google Forms®, 18 questions were sent to veterinarians to gather information on variables of clinical interest, such as the degree of knowledge on the disease, diagnostic test, therapies used, treatment resistance, and concomitant diseases. Questions also involved epidemiological information such as gender of affected animals, condition of free-roaming dogs, and whether the dogs were urban or rural. For geographic location, we used official information of the Colombian National Administrative Department of Statistics (DANE), which divides the country into five bioregions. Respondents were selected via Internet search and by contacting the main veterinarian associations in the country. With non-probability sampling, the questionnaire was sent by email to 950 veterinarians, but only 176 forms were completed in the following 4 weeks. Only 152 met the criteria for inclusion in the study, namely, at least 16 complete responses. Data were collected in Excel ® format for easiness of handling.

To determine CTVT prevalence in each region and the human/canine ratio, we used the data reported by respondents and the official DANE data on the projected population density for 2015 (DANE, 2005). Because of lack of data on the dog population in Colombia and taking into account studies conducted in Guatemala, Italy, Ireland, Venezuela, Argentina, and Brazil, we calculated an average rate of 4.6 people per canine (Medina *et al.,* 2002; Alves *et al.,* 2005; Slater *et al.,* 2008; Downes *et al.,* 2009; Zumpano *et al.,* 2011; Pulczer *et al.,* 2013). Data on the calculation of canine population is shown in Table 1.

The results are shown in terms of ratios and proportions to reveal the trend in each questionnaire

response. In addition, the average number of CTVT cases was statistically compared using univariate ANOVA, with the number of cases as the response variable and several others as factor variables (region, type of organization, clinical support, regression, and treatment). In case of significant differences, the Tukey test was applied to establish the difference. Subsequently, the different regions were compared by analysis of automatic classification (cluster analysis). The XLSTAT 2014 software was used for one- and two-dimensional analyses. SPAD 8.0 software was useful for cluster analysis by region.

## Results

Of the 152 eligible surveys, 128 (84.2%) corresponded to private clinics, 15 (9.9%) from Veterinary Medicine schools, 6 (3.9%) from veterinary diagnostic laboratories, and only 3 (2.0%) from foundations dedicated to animal welfare.

Most answers (131) came from the Andean region, whereas 10 forms were obtained from the Caribbean region, 5 from the Amazon, 5 from the Pacific, and 2 from Orinoco. The estimated number of CTVT cases encountered by veterinarians was 1,135. Most occurred in the Andean region with 862 cases (75.9%), followed by the Pacific with 110 cases (9.7%), the Amazon with 79 cases (7.0%), the Caribbean with 64 cases (5.6%), and Orinoco with 20 cases (1.8%) (Figure 1).

### *Colombian CTVT prevalence*

The prevalence was obtained as a ratio of the sum of the cases observed by each veterinarian to the number of canines calculated for the same Colombian region. The overall prevalence of CTVT for the country was estimated to be 0.01%; the Amazon region was first (0.17%), followed by the Pacific (0.084%), Orinoco (0.019%), Andean (0.014%), and Caribbean (0.006%) regions. Data for the calculation of CTVT prevalence is presented in Table 1.

Thus, based on the information provided by the respondents, the canine/human ratio was less than 1 for 65.8% of respondents (100 forms), equal to 1 for 27% (41 forms), and greater than 1 for 7.2% (11 forms).

**Table 1**. Prevalence of CTVT calculated for Colombia in different biogeographic regions.

| Region | Human Population * | Canine Population ** | CTVT Cases *** | Relative Prevalence |
|---|---|---|---|---|
| Amazon | 213,267 | 46,362 | 79 | 0.170 |
| Pacific | 600,000 | 130,435 | 110 | 0.084 |
| Orinoco | 484,429 | 105,311 | 20 | 0.019 |
| Andean | 28,630,855 | 6,224,099 | 862 | 0.014 |
| Caribbean | 5,334,430 | 1,159,659 | 64 | 0.006 |
| Total | 35,262,981 | 7,665,865 | 1135 | 0.015 |

*Calculated for Colombia in 2015 by the Departamento Administrativo Nacional de Estadística (DANE, 2005)

**Calculated for Colombia in 2015 (4.6 humans per canine; see the methodology)

***Cases of CTVT reported in the present work

According to veterinarians who reported how many CTVT cases were observed in a year, most (65.8%) reported between 0 and 8 cases, a quarter (24.3%) said they had seen between 9 and 15 cases, a few (9.2%) said they saw between 16 and 40 cases, and only one veterinarian (0.7%) reported having seen 80 cases; notably, the latter respondent was located in the jungle area of the border between Colombia and Panama. Table 2 shows higher average of cases in regions with lower human population (Orinoco, Pacific, and Amazon). The high variability in the number of cases by region also indicates a marked difference among the answers given in each place.

### *Epidemiology of Colombian CTVT presentation*

In relation to sex, almost half of the respondents (44.8%) said there was no difference between the number of males and females. However, 35.5% of the veterinarians believed that males were more affected, while 19.7% believed that females were more affected. We found significant differences about the perception of the gender of affected animals according to the veterinarians (p=0.002). Regarding the reproductive status of the animals, 28 of the veterinarians surveyed (18.4%) answered that most of their treated animals were neutered and the remaining 124 (81.6%) reported that these animals were intact.

**Table 2.** Number of CTVT cases according to the surveys completed in Colombia.

| Statistic - Cases number | Region | | | | | |
|---|---|---|---|---|---|---|
| | Andean | Caribbean | Amazon | Pacific | Orinoco | Total |
| Surveys completed | 131 | 10 | 5 | 4 | 2 | 152 |
| Minimum | 0 | 3 | 4 | 2 | 0 | 0 |
| Maximum | 40 | 15 | 20 | 80 | 20 | 80 |
| Average | 6.6 | 6.4 | 15.8 | 27.5 | 10.0 | 7.5 |
| Coefficient of variation | 99.5% | 74.3% | 39.3% | 112.7% | 100.0% | 119.7% |

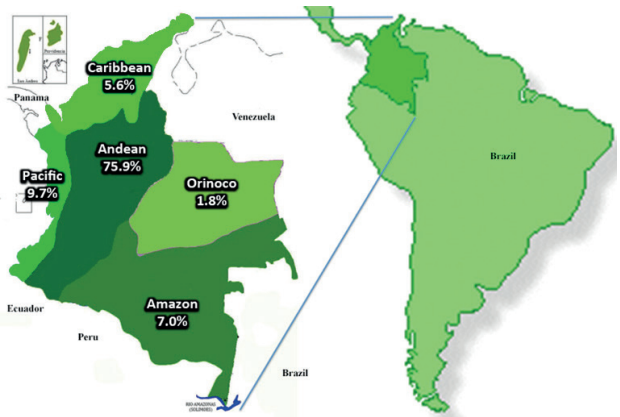


**Figure 1**. Map of estimated CTVT prevalence in different regions of Colombia. The greatest number of cases coincided with the largest number of veterinarians surveyed (in the Andean region), as well as with the largest human population in the country.

Regarding stray dogs in each area, 69.7% of respondents reported the presence of these animals. According to the respondents, most CTVT cases were found in urban areas (75.7%). Similarly, 11.8% of respondents said the cases came from rural areas, 9.2% from semi-rural areas, and 3.3% did not respond.

*Clinical behavior of CTVT in Colombia*

CTVT cases were reportedly accompanied by parasites; ectoparasite infestation was the most frequent, including fleas, ticks, and lice. Presence of *Demodex* (*canis* and *folliculorum*) infestation was also noted. The respondents also reported the presence of blood parasites such as *Trypanosoma* sp., *Babesia* sp., and *Ehrlichia canis*. Regarding gastrointestinal parasites, the veterinarians reported the presence of *Giardia*, *Ancylostoma caninum*, *Dipylidium caninum*, *Toxocara canis,* and Coccidia (mainly *Isospora* sp). Internal or external parasites or both were reported in 32.0, 18.0, and 12.0% of animals, respectively. On the other hand, only two vets said they had seen anemia and thrombocytopenia; other two saw cases accompanied by emaciation and malnutrition associated with abandonment conditions. One respondent said CTVT animals presented some degree of immunosuppression.

*Diagnosis tests used for CTVT in Colombia*

To diagnose CTVT, a high percentage of respondents (47.4%) said that they used cytology, followed by clinical observation and histopathology at 26.3 and 13.1%, respectively. A small proportion of veterinary surgeons (12.5%) combined clinical diagnosis with cytology and histopathology, whereas 0.7% did not answer this question.

*Biological behavior of CTVT in Colombia*

An important aspect of the biological behavior of CTVT is the ability of the immune system to generate spontaneous tumor regression. However, most respondents said that they had not seen this type of behavior in any of the animals that they had attended. Additionally, no reported cases of distant metastasis were seen.

With regards to treatment, 91 of the veterinarians (59.9%) said they used vincristine as the only means of treatment, 32 (21.1%) used a combination of vincristine and surgery, and 27 (17.8%) combined more than three procedures among chemotherapies, homeopathy, surgery, and a combination of chemotherapy-immunotherapy. One respondent (0.7%) used surgery alone as treatment while another (0.7%) used chemotherapy with doxorubicin.

Veterinarians who used vincristine (alone or combined with surgery) needed a minimum of two doses and a maximum of eight. In the statistical analysis, a significant difference was found ($p<0.001$) between the proportion of vets that used vincristine as the only treatment and those who used it in combination with surgery.

## Discussion

Although CTVT cases occurred throughout the country, the estimated prevalence in this study did not exceed 7.05% per annum, similar to results obtained of relative diagnostic percent (RDP) in other Colombian studies: at Universidad de Antioquia in Medellín, CTVT comprised 4.54% of all neoplasms in dogs (Ferreira and Pedraza 2003); in Villavicencio, 8.6% of neoplasms in dogs corresponded to this transmissible tumor (Bravo *et al.,* 2010); and in Boyacá, 2.7% of street canines had this tumor (Sánchez *et al.,* 2014). The staff at Universidad de Caldas in Manizales determined 40 animals were affected by CTVT in 2014, corresponding to 1% of all dogs treated at the veterinary hospital and 9.2% of the recorded cases was associated with neoplasms (unpublished data).

According to the Professional Council of Veterinary Medicine in Colombia (COMVEZCOL), 70% of Colombian veterinarians are working in the Andean region, which explains why most surveys originated from this region. Similarly, the regions with the fewest veterinaries (Amazon, Pacific, and Orinoco) showed the lowest number of completed surveys. The highest estimated prevalence of CTVT was found in the Andean region, whereas the Amazon and Pacific regions proportionately had the highest number of cases because the few veterinarians who responded reported they had seen many CTVT cases. This large number of cases may be explained by the fact that they are remote regions, with few veterinarians, without access to medicines (vincristine), and a high population of wandering dogs that keep the disease circulating in the environment.

Significant differences were observed regarding sex of affected animals, with imbalance stating that the disease was more prevalent in males. However, it could be that the disease is easier to diagnose in males than in females, or at least the recovery or lack thereof is easier to verify in males, resulting in fewer females received chemotherapy. Analysis of the presence of stray dogs revealed an apparently high proportion of these animals in Colombia. Given that a high proportion of these dogs are affected by CTVT (Strakova and Murchison, 2014), it is necessary to decide whether CTVT should be included in stray dog control, taking into account that most of the affected animals live in urban areas. Regarding reproductive status, it is known that intercourse is the typical infection route. Nevertheless, there were castrated animals affected by CTVT. It is possible that their lower immunity, which characterizes stray animals due to malnutrition, concomitant diseases, and stress, allows greater susceptibility to the tumor, or they might have been affected before neutering and the tumor was "dormant" for more than one year. In addition, a number of respondents observed ecto and endoparasites in animals affected by CTVT and, as reported by Strakova and Murchison (2014), this condition could be related to abandonment or income, because the poorest regions reported the largest number of cases.

On the other hand, clinical observation is still widely used to diagnose CTVT. However, cytology has gained importance as a method for disease diagnosis, as reported by most respondents. The understanding of the techniques available for diagnosis is constantly improving. In addition, the easy access and low cost of reagents make cytology a useful tool for CTVT diagnosis. No differences have been reported in the phenotype of neoplastic cells (CTVT lymphocytoid and plasmacytoid), as suggested by Florez *et al.,* (2012).

Regarding biological behavior of CTVT, Colombian veterinarians have not seen spontaneous regression of the tumor. However, considering that the main reason for consultation is genital bleeding, veterinarians should set up an actual treatment regimen at the very least. The owner would most almost certainly expect this. Placing the animal under observation without treatment for several weeks to determine whether spontaneous regression of the lesion occurs is not the appropriate course of action for owners who merely want relief for their pet. In the case of wandering canines, improvement in living

conditions (food, deworming, tranquility) could be enough to allow their immune system to trigger spontaneous regression of the lesion. However, only clinical trials can determine what happens in this regard. Some veterinarians suggest that spontaneous regression of lesions could explain the absence of sick animals in the same geographical area where the animals with CTVT were treated. However, there are no reports of such regression.

A high percentage of respondents depend on vincristine (alone or in combination) for treating CTVT. In Brazil, there are reports that cancer cells have acquired resistance because of chemotherapy mismanagement, either due to lower than necessary frequency of administration or administration of smaller than recommended amounts of chemotherapy drugs. For complete tumor elimination, a weekly dose of vincristine of 0.5 to 0.75 mg/m$^2$ body surface area is required for as long as 4 to 8 weeks. However, one or two doses limit tumor growth and eliminate the main clinical sign (genital bleeding), which could mistakenly be interpreted as a "cure" and ultimately leave the animal without a complete treatment course. In addition, the use of lower than therapeutic doses can generate chemotherapeutic agent resistance (Sousa *et al.,* 2000, Montoya *et al.,* 2014). Similarly, there have been reports of the coincidence of resistance with plasmacytoid cytomorphology, leading to hypotheses about cell transformation triggering resistance to vincristine (Eze *et al.,* 2013). In our study, very few veterinarians reported encountering some type of resistance using the therapeutic dose, suggesting that the phenomenon of resistance is generally not a serious problem in Colombia. We are now trying to establish whether there are differences in the expression of molecules associated with resistance in samples from Brazilian and Colombian canines. This information could help identifying a solution to the resistance phenomenon affecting our neighboring country. In Colombian provinces such as Valle and Risaralda, homeopathic products and homotoxicology therapy derivatives were used as an alternative to difficult-to-obtain chemotherapy, whereas remote sites tended to opt for surgery or euthanasia. Surgery is not the treatment of choice due to the fragility of the tissue, the gaping wound, difficult healing and the tumour is easily transplanted to surgical wounds (Das, 2000). Moreover, no studies have shown the mechanism of action of homeopathic agents or homotoxicology and their usefulness in treating CTVT is unproven.

Our results indicate a moderate prevalence and incidence of CTVT in Colombia and provide key clinical veterinary information on the medical approach and diagnosis of the disease. Our data also generate alternatives for establishing effective measures aimed at controlling and reducing disease prevalence in the country.

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**Conflicts of interest**

The authors declare they have no conflicts of interest with regard to the work presented in this report.

**References**

Alves MCGP, Matos MRD, Reichmann MDL, Dominguez MH. Estimation of the dog and cat population in the State of São Paulo. Rev Saúde Pública 2005; 39(6):891-897.

Bravo D, Cruz-Casallas P, Ochoa J. Prevalence of neoplasm in canines in the University of the llanos, during 2004 to 2007. Rev MVZ Córdoba 2010; 15(1):1925-1937.

Decker B, Davis BW, Rimbault M, Long AH, Karlins E, Jagannathan V, Reiman R, Parker HG, Drögemüller C, Corneveaux JJ, Chapman ES, Trent JM, Leeb T, Huentelman MJ, Wayne RK, Karyadi DM, Ostrander EA. Comparison against 186 canid whole-genome sequences reveals survival strategies of an ancient clonally transmissible canine tumor. Genome Res 2015; 25(11):1646-1655.

Cantazaro A, Di Salvo A, Steagall PV, Zampini D, Polisca A, Della Rocca G. Preliminary study on attitudes, opinions and knowledge of Italian veterinarians with regard to abdominal visceral pain in dogs. Vet Anaesth Analg 2016;43(4):361-70. doi: 10.1111/vaa.12326.

COMVEZCOL, Consejo Profesional de Medicina Veterinaria y Zootecnia. Situación actual de la Medicina Veterinaria, Medicina Veterinaria y Zootecnia y Zootecnia en Colombia. Bogotá D.C. 2015.

Das U and Das AK. Review of canine transmissible venereal sarcoma. Vet Res Commun 2000; 24(8):545-556.

Departamento Administrativo Nacional de Estadística. Proyecciones nacionales y departamentales de población 2005-2020. 2005 [access date: July 2016]; URL: https://www.dane.gov.co/files/investigaciones/poblacion/proyepobla06_20/7Proyecciones_poblacion.pdf

Downes M, Canty MJ, More SJ. Demography of the pet dog and cat population on the island of Ireland and human factors influencing pet ownership. Prev Vet Med 2009; 92(1): 140-149.

Eze CA, Kene ROC, Anyanwu HC. Comparative efficacy of surgery, vincristine sulphate and combined therapy of levamisole and Bacille Calmette Guerin vaccine in the treatment of transmissible venereal tumour-infected dogs. Comp Clin Pathol 2014; 23(5):1263-1267. doi:10.1007/s00580-013-1773-x

Florez MM, Pedraza F, Grandi F, Rocha NS. Cytological subtypes of canine venereal transmissible tumor. Vet Clin Pathol 2012; 41(1):3-5.

Ferreira GM, Pedraza FJ. Caracterización y análisis de las neoplasias registradas en el Laboratorio de Patología Animal de la Universidad de Antioquia durante 30 años (1968–1998). In: Ferreira De La Cuesta GM. Patología Veterinaria. Medellín: Editorial Universidad de Antioquia; 2003. p. 580-581.

Hang JF, Liang WY, Hsu CY, Lai CR. Integrating a Web-Based Whole-Slide Imaging System and Online Questionnaires in a National Cytopathology Peer Comparison Educational Program in Taiwan. Acta Cytol 2015; 59(1):278-283.

Madewell BR, Theilen GH. Skin tumors of mesenchymal origin. In: Theilen GH and Madewell BR, Editors. Veterinary Cancer Medicine. 2nd ed. Philadelphia: Lea & Febiger; 1987. p. 282-309.

Martínez MM, Ballut JC, Cardona JA. Tumor venéreo transmisible (TVT) de localización extragenital. Rev MVZ Córdoba 2002; 7(1):168-170.

Medina A, García A, Rodríguez L, Núñez L, Pérez-Barrientos M, Castejón O. Identificación de áreas de riesgo en rabia urbana en los Municipios Maracaibo y San Francisco del Estado Zulia. Rev Cientif FCV-LUZ 2002; 12(6):688-698.

Mialot JP. Données pratiques de physiologie sexuelle. In: Pathologie de la reproduction des carnivores domestiques. Maisons-Alfort. Edition Le point vétérinaire; 1984. p. 17-28.

Montoya FLM, Haline BF, Sousa NR. Tumor venéreo transmissível canino: expressão dos genes MDR-1, TP53 e da família Bcl-2 e suas implicações no comportamento biológico e terapêutico. Rev CES Med Zootec. 2014; 9(2):281-294.

Moulton JE. Tumours of Domestic Animals, 3rd ed. Berkeley and Los Angeles (CA): University of California Press; 1990.

Murchison EP, Wedge DC, Alexandrov LB, Fu B, Martincorena I, Ning Z, Tubio JMC, Werner EI, Allen J, de Nardi AB, Donelan EM, Marino G, Fassati A, Campbell PJ, Yang F, Burt A, Weiss RA, Stratton MR. Transmissible dog cancer genome reveals the origin and history of an ancient cell lineage. Science 2014; 343(6169):437-440.

Murgia C, Pritchard JK, Kim SY, Fassati A, Weiss RA. Clonal origin and evolution of a transmissible cancer. Cell 2006; 126(3):477-487.

Ostrander EA, Davis BW, Ostrander GK. Transmissible tumors: breaking the cancer paradigm. Trends Genet 2016; 32(1):1-15.

Pulczer AS, Jones-Bitton A, Waltner-Toews D, Dewey CE. Owned dog demography in Todos Santos Cuchumatán, Guatemala. Prev Vet Med 2013; 108(2):209-217.

Ramírez-Bonilla FT, Sotto-Gasca LG, Manjarres-Gomez NR, Artunduaga-Mellizo LJ, García-Trujillo R. Reporte de caso: tumor venéreo transmisible en perro. REDVET rev electron vet 2015; 16: 1-11. http://www.veterinaria.org/revistas/redvet/n010115/011506.pdf

Salamanca S, Santader-Baquero A, Triana-García PA, Romero S, Rondón-Barragán IS. Tumor venéreo transmisible (TVT) con metástasis pulmonar: reporte de caso. Orinoquia 2008; 12(2):162-170.

Sánchez A, Díaz C, Sánchez F. Prevalencia del Tumor Venéreo Transmisible en caninos en el municipio de Soracá-Boyacá. Proceedings of the III Seminario Internacional y IV Nacional de Investigadores en Salud y Producción Animal; 2014 Sep 17-19; Tunja, Colombia: Ed. Universidad Pedagógica y Tecnológica de Colombia; 2014.

Slater MR, Di Nardo A, Pediconi O, Dalla Villa P, Candeloro L, Alessandrini B, Del Papa S. Cat and dog ownership and management patterns in central Italy. Prev Vet Med 2008; 85(3):267-294.

Sousa J, Saito V, Nardi B, Rodaski S, Guerios S, Bacila M. Características e incidência do tumor venéreo transmissível (TVT) em cães e eficiência da quimioterapia e outros tratamentos. Arch Vet Sci 2000; 5(1):41-48.

Strakova A, Murchison EP. The changing global distribution and prevalence of canine transmissible venereal tumour. BMC Vet Res 2014; 10(168):1-10. doi: 10.1186/ s12917-014-0168-9

Wang W, Russell A, Yan Y, Global Health Epidemiology Reference Group (GHERG). Traditional Chinese medicine and new concepts of predictive, preventive and personalized medicine in diagnosis and treatment of suboptimal health. EPMA J 2014; 5(4):1-9. doi: 10.1186/1878-5085-5-4.

Zumpano R, Tortosa A, Degregorio OJ. Estimación del impacto de la esterilización en el índice de crecimiento de la población de caninos. Rev Inv Vet Peru 2011; 22(4):336-341.